THE INSTITUTE OF PHYSICS BULLETIN

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Published by The Institute of Physics and The Physical Society

Appointments Vacant

The inclusion of particulars of a vacancy must not be taken to imply that the Institute necessarily approves of the terms offered or that might be offered. Candidates should satisfy themselves that these are satisfactory, and they may always refer to the Institute for advice.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY
LONDON, S.W.7

RESEARCH ASSISTANT required in the Geophysics section of the Geology Department. Applicants, who must have a physics degree and a good knowledge of electronics, will be engaged in laboratory and field work and will, after a probationary period, have facilities for working towards a higher degree. The activities of the section at present include instrumentation for rockets and satellites, and various aspects of marine geophysics. Salary will be in the range £700 – £950 p.a., according to qualifications and experience, plus F.S.S.U. and London allowance. Applications, with full particulars and names of two referees, to the Professor of Geophysics, by July 25, 1960.

HOSPITAL PHYSICIST required in DEPARTMENT OF PATHOLOGY for radioisotope work covering a wide field. Candidate with one or two years' previous experience preferred; salary scale with two years' experience £830 to £1,035 p.a. plus London Weighting (£40/50) (Scale now under review). Applications with details of qualifications and experience and names of two referees to Group Secretary, Queen Elizabeth Hospital for Children, Hackney Road, London, E.2.

T.I. RESEARCH LABORATORIES
HINXTON HALL, CAMBRIDGE

PHYSICISTS required to lead a small group developing instruments and electronics to meet the special needs of the above fundamental research laboratories, and to undertake special research investigations in this field. Further details and application form from the Secretary, quoting reference P/163.

EXPERIMENTAL OFFICERS (minimum age 27) and ASSISTANT EXPERIMENTAL OFFICERS required in War Office Establishments mainly in South England. Experimental work in chemistry; physics; electronics; electrical and mechanical engineering; and survey computing. Vacancies in Sevenoaks, Salisbury, Chertsey, Farnborough (Hants.), Feltham, Didcot; and S.E. London. Qualifications: G.C.E. (Advanced Level) Pass Degree, H.N.C. or City and Guilds Final Certificate of grouped course (Advanced graduates) in Telecommunications. For survey computing work, Mathematics and Geography at G.C.E. "A" is useful. Salary ranges (male) Experimental Officer £954 to £1,166. Assistant Experimental Officer £382 (age 18) to £830 p.a. Higher rates in London Area. Women's scales the same by 1961. Possibility of pensionable posts and promotions. Application forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.288/OA.

BELFAST EDUCATION COMMITTEE
COLLEGE OF TECHNOLOGY

Principal: D. H. Alexander, O.B.E., F.C.G.I., M.Sc., Wh.Sch., M.I.Mech.E.

Applications are invited for the position of HEAD OF THE DEPARTMENT OF TEXTILE INDUSTRIES in the College of Technology, Belfast. Though chiefly concerned with flax and linen, the department is also equipped to deal with the study of other natural and synthetic fibres, and is now being reorganized to meet the needs of the modern textile industry. The person appointed will be required to advise on this reorganization and to assist in carrying it out. He will also be expected to work in close contact with local industry and will be given facilities for carrying out research and consulting work. Applicants should have had a scientific training to graduate level, not necessarily in textile technology, but possibly in engineering or physics. They should also have experience in industry. An otherwise suitable candidate, with insufficient experience in the field of textiles, may be given assistance to enable him to spend some time in textile works or research establishments. The present salary attached to the position is £1,600 per annum rising by annual increments of £50 to £1,800 per annum, and approved service elsewhere will be taken into account in fixing the commencing salary. Application forms and full particulars may be obtained from the Principal, College of Technology, Belfast 1, with whom applications should be lodged not later than July 30, 1960. Canvassing is strictly forbidden and will disqualify.

J. Stuart Hawnt, Director of Education.

PHYSICISTS REQUIRED. Opportunities are available for two graduates with first or second class honours degrees in Physics or Mathematics to carry out research in classical physics, applied electronics and applied mathematics. Present investigations include (*a*) studies of the physical properties of brittle solids, the behaviour of fine particles, data handling and automatic control, and (*b*) the analytical and numerical solutions of both linear and non-linear equations arising from problems in heat flow, reaction kinetics, and also on a variety of other problems in applied mathematics. Opportunity to work toward higher degrees may be provided. Full and rapid publication of results is encouraged. Successful applicants will be expected to be able to organize their own investigations. Salary according to age and qualifications up to £1,250 at age 30 with good prospects of advancement. Graduates or final year students should apply to the Assistant Secretary, Ref. G27, British Coal Utilisation Research Association, Randalls Road, Leatherhead.

UNIVERSITY OF WESTERN AUSTRALIA

CHAIR IN THEORETICAL PHYSICS

Applications are invited for appointment to the above-named Chair in the Department of Physics. The salary for a Professor is at present £A3,500 p.a. but it is expected that this amount will be increased in the near future to approximately £A4,000 p.a., superannuation will be similar to F.S.S.U. It is important that intending applicants obtain details of the procedure to be followed in applying for the post and a copy of the Conditions of Appointment. This information is available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on August 31, 1960.

INSTRUMENT DEVELOPMENT

We want the assistance of two ENGINEERS or applied physicists who are looking for real opportunity and who like the atmosphere of a small Company, for work on inventing, developing and taking to a production stage, controls and instruments for industrial processes. Should have a good basic knowledge with ability to think quickly and widely. Good familiarity with transistor techniques required and knowledge of optics and mechanical design or industrial instruments an advantage. Non-contributory Pension Scheme available. Please reply stating your requirements and other details to :—Chief Engineer, Elcontrol Limited, Wilbury Way, Hitchin, Herts.

UNIVERSITY OF CAMBRIDGE

Applications are invited for a SENIOR ASSISTANT in Research in the Cavendish Laboratory. The qualifications required are a degree or substantially equivalent qualifications in Physics or Electrical Engineering or other approved subject, and experience in previous employment. Particulars may be obtained from Dr. F. B. Kipping, Chemical Laboratory, Lensfield Road, Cambridge. Applications will close July 15, 1960.

OPPORTUNITIES IN THE U.S.A. SEMICONDUCTOR DEVICE SCIENTISTS OR ENGINEERS. Five to ten years development experience in diodes, transistors. Knowledge of Ge, Si, compound semiconductor components. Familiarity with fabrication methods/applications very desirable. These are outstanding technical/financial opportunities in an old established component manufacturing concern in the U.S.A. The Company's representatives will visit London in July. Please send particulars to G. V. Planer Ltd., Windmill Road, Sunbury-on-Thames, Middlesex.

ENGLISH ELECTRIC VALVE COMPANY LIMITED

CHELMSFORD, ESSEX

PHOTOCONDUCTIVITY RESEARCH

A Physics graduate with a good honours degree is required to fill a position with a small Group starting a fundamental study of the properties of photoconductors.

Whilst previous experience in this field would be useful it is not essential.

Details of education, subsequent experience, age, and published papers if any should be forwarded to

DEPT. G.P.S., MARCONI HOUSE, 336/7 STRAND, LONDON, W.C.2

quoting reference IP 1595D.

NUCLEONIC INSTRUMENTATION

PHYSICIST

with some experience in electronics, required for work in connection with the measurement and applications of nuclear radiations, with particular reference to applications of radioisotopes to research and instrumentation problems. Good degree required. Salary up to £1,150, with good prospects of advancement. Liberal leave allowance and good working conditions in attractive semi-rural surroundings close to London. Superannuation scheme.

Applications, quoting reference TPF, to the Director,
J. Thomson, M.A., D.Sc.,
British Scientific Instrument Research Association,
Sira, South Hill, Chislehurst, Kent.

COMMONWEALTH **OF AUSTRALIA**

WEAPONS RESEARCH ESTABLISHMENT

Research on Instrumentation in Aerodynamics

The Department of Supply invite applications for the following vacancy at the Weapons Research Establishment, Salisbury, South Australia:—

Position and Salary: SCIENTIFIC OFFICER, GRADE 3: £2,005/2,265 (Aust.)

Duties: (pos. No. 69): Research on design and development of physical instruments, mainly mechanical and optical for aerodynamic research in wind tunnels and by free flight and rocket techniques.

Qualifications: Honours degree in Science, with Physics and Mathematics as major subjects, together with some experience in the above field.

Conditions: Under specified conditions, first class air/sea transport for the appointee and dependants (wife and dependent children) will be provided by the Commonwealth. Assistance will be given in obtaining housing accommodation.

Contract Employment: If desired by the successful candidate consideration may be given to entering into an agreement for a three (3) for five (5) year contract of employment in Australia. In this case the Commonwealth will bear the cost of return fares; together with the cost of removing the successful applicant's furniture and effects up to a maximum cost of £500 (Aug.): £250 each way.

Applications: Forms obtainable from the Senior Representative (AV.67/6). Department of Supply, Australia House, Strand, London, W.C.2, with whom completed applications should be lodged by July 29, 1960.

CENTRAL ELECTRICITY GENERATING BOARD

RESEARCH AND DEVELOPMENT DEPARTMENT

Research Laboratories, Leatherhead, Surrey

ELECTRONICS AND INSTRUMENT SECTION

PHYSICISTS

are required for long term research into the magnetic properties of transformer steels. The work involves a fundamental study of the magnetic and mechanical properties of transformer core materials in relation to the basic mechanism of noise production. The successful candidates will be responsible for initiating this work and developing techniques aimed at reducing the noise emanating from conventional transmission and distribution transformer cores.

Applicants must have experience in magnetic measurements and possess a University degree.

Salaries on scales within the range £1,195 - £1,775 p.a. or, up to £1,300 p.a. according to duties and responsibilities.

There are good opportunities for promotion to higher grades. Where necessary consideration may be given for financial assistance towards house purchase.

Applications stating age, qualifications, experience, present position and salary, to the Personnel Officer, 24/30 Holborn, London, E.C.1, as soon as possible. Envelopes should be marked " Confidential Ref. PB/205."

ENGLISH ELECTRIC VALVE COMPANY LIMITED

CHELMSFORD, ESSEX

MICROWAVE RESEARCH

A leader for a team required in microwave tube field. He will control fundamental work leading to new devices, and work on new devices. Freedom to develop new ideas.

Must have good honours degree and some published work in the microwave field.

Post would suit lecturer.

Details of education, subsequent experience, age and published papers should be sent to

DEPT. G.P.S., MARCONI HOUSE, 336/7 STRAND, LONDON, W.C.2

quoting reference IP 1595C.

THE INSTITUTE OF PHYSICS

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Published by The Institute of Physics and The Physical Society

The Physics Department of the Christie Hospital and Holt Radium Institute, Manchester

W. J. MEREDITH

M.Sc., F.Inst.P.

Chief Clinical Physicist, Christie Hospital and Holt Radium Institute

ON THE gate-post of a large house, in the Withington suburb of Manchester, is a plate on which are the words "Walton House. Physical Laboratories of the Christie Hospital and Holt Radium Institute." In this house, which is just across the road from the hospital, and in the inevitable prefabricated buildings in its garden, as well as in a number of small rooms scattered throughout the hospital, 13 physicists and 18 technicians work. They are engaged in the applications of physics to the problems of radiotherapy and in research into fundamental problems arising in a study of the action of ionizing radiations on living tissues. Officially—that is, for salary purposes !—these people are grouped under three headings, but their activities are so intermingled and interdependent that they can only be thought of as a whole.

The employment of physicists in hospitals is not a recent innovation. Over sixty years ago a small number were teaching physics to medical students in some of our leading hospitals. However, it was not until about thirty years ago that appreciable numbers of physicists began to be employed specifically to apply their subject to clinical problems, especially in radiotherapy. These men and women set the pattern for most of what has followed, by establishing a tradition which has remained a distinctive feature of British Medical Physics. This is the principle of close collaboration between the physicist and his medical colleagues, and his intimate connection with clinical work. It is therefore difficult to understand completely the present position and status of a hospital physics department without some knowledge of the history and growth of the medical unit which it serves.

In the early part of this century much public effort was directed towards the raising of funds for purchasing radium for our hospitals. One such effort resulted, in 1915, in radium treatments being started in a basement of the Manchester Royal Infirmary. By 1921 a move to larger accommodation in a separate building became necessary, and an X-ray therapy machine was added to the facilities of the young Radium Institute. An important feature of the developing Institute, which has been maintained throughout its existence, was its insistence that radiotherapy should be centralized. This is now widely accepted but its early adoption in Manchester gave the Institute a great advantage over many centres where the initial organization was haphazard and diffuse.

The logical consequence of this policy came in 1933 when the Radium Institute amalgamated with the Christie Cancer Hospital (a much older foundation) to form the Christie Hospital and Holt Radium Institute and both moved to a newly built hospital in Withington to form one of the world's largest cancer treating centres.

Throughout its history the Institute has had associated physicists, though at times the association was rather loose, and in the beginning the physicists were primarily

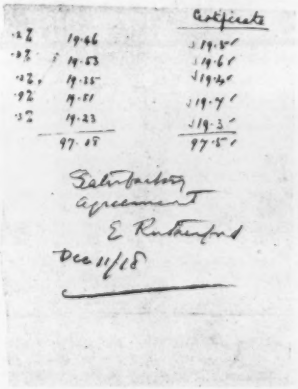

Fig. 1. *A reminder of our earliest physicist.*

concerned with the working of the radon separation plant. (And here one would like to turn aside from the main narrative to pay tribute to the debt that we owe to Dr. H. P. Walmsley for his help and guidance with this plant up to 1950 when the Radiochemical Centre at Amersham became responsible for national supplies of radon and we were able to dispense with a somewhat hazardous chore.) It was in these early days that the Institute had its most distinguished associate physicist, of whom the then medical director has written " We used to get advice from Sir Ernest Rutherford. He was a most understanding, co-operative and helpful man, which, in those days, was unusual for a physicist(!). I think the physicists knew nothing about our work and assumed we were very ignorant. Dr. Marsden (now Sir Ernest Marsden) also used to help." One believes that the strictures of the penultimate sentence no longer apply to-day !

Of the era the only remaining evidence is a Post Office box and a resistance box of high quality, and the slip of paper shown in Fig. 1. On this Rutherford noted down his estimates—right hand column—of the strength of some radium tubes supplied to the Institute by the Standard Chemical Company of the U.S.A., whose estimates appear in the left hand column. It had been agreed that Rutherford's measurements should be accepted as a basis for the payment for the sources.

A little later the Institute enjoyed, for a short time, the services of a full-time physicist, Hartley Lupton, but on his untimely death no successor was appointed and such services as were required were provided by the University Physics Department under the direction of Professor (now Sir Lawrence) Bragg.

Elsewhere, however, events were moving rapidly. The British X-ray and Radium Protection Committee (the first of its kind in the world and the instigator of international action) had been set up to formulate safety codes and, by 1928, the roëntgen had been accepted internationally (again through British leadership) as the unit of X-ray quantity. The need for accurate dosage measurements and control was being realized. In such a " climate " of development it was natural that, when space became available in the new Institute, a physics department be reformed, and H. M. Parker (now with the General Electric Corporation of America, at Hanford, Wash.), was appointed full-time physicist.

In the new hospital the department was housed in a single room close to the radium safe and the radon separation plant (soon removed to a separate building), an arrangement that reflected the earlier responsibilities of the department but little appreciation of the need for low radiation background in the maintenance of accurate dosemeter standards. Within a few years, therefore, when extensions to the hospital were built, a move was made to better sited and more adequate accommodation and at the same time a much needed workshop was set up in the basement and a well trained instrument-maker added to the staff.

The seed thus planted flourished and grew steadily in size and scope so that in 1946 Walton House was acquired, later to be augmented by out-buildings and a number of single rooms in various parts of the hospital. Though from many points of view the scattering of the department is far from ideal there is one advantage, in so far as it enables us to keep a closer contact with the clinical and research departments which we serve.

In view of this historical background it is not surprising that most of our original contributions have been closely linked with radiotherapy, and often written in collaboration with radiotherapists. In the 1930's a series of papers mainly by H. M. Parker and Dr. Ralston Paterson, the Medical Director, set superficial, intra-cavitary, and interstitial radium therapy on a systematic physical basis, and there can be little doubt that this " Manchester System," as it is usually called, is the most important contribution so far, to this field of radiotherapy. At the same time methods were developed for controlling dosage in interstitial radium treatments, either by reconstruction or radiographic methods and these, like the " Manchester System," have gained wide acceptance throughout the world.

As higher generating voltages became available in the middle '30's, X-ray therapy became increasingly important and the department was one of the early investigators of the distribution of X-rays throughout a scattering medium. Later, in collaboration with another hospital, a system was devised for calculating charts of these distributions (isodose curves) from basic central ray data. This work enabled a much wider range of these charts to be available than hitherto in any department, and played an important part in raising the general level of accuracy of radiotherapy.

Although radiotherapeutic problems of this sort, and an increasing amount of their routine application to individual treatments, absorbed a large part of the department's time, more fundamental problems were not neglected. Active help was given with the physical problems of the small group of research workers associated with the hospital, especially in radiobiology and biochemistry. With Dr. W. M. Dale, for example, some of the early work on the action of ionizing radiations on solutions of enzymes was carried out. This work helped to lay the foundation of the theory of the Indirect Action of Radiation on solutions and hence on living cells, and also demonstrated the protective action of added solutes.

By the end of the war the need for this collaboration had grown sufficiently to warrant the formation of a special group, under Dr. C. W. Gilbert, to concentrate on research problems including further fundamental physical research. At the same time the existing group was freed to concentrate on the routine and research problems directly associated with clinical radiotherapy. This is the pattern to-day.

On the clinical side much attention has been, and is being, given to the application of electronics to clinical problems especially in the field of dosemetry. Notable examples of this have been the development of integrating dosemeters and dose-controlled exposure timers using low-inertia electric motors, and the designing of dosemeters employing tiny anthracene crystals as scintillators. The former have greatly increased the accuracy of X-ray treatments whilst the latter, by facilitating measurements close to radium sources in body cavities, have made these treatments more reliable and have practically eliminated the dangers of local regions of accidental high intensity. In these instruments, as in any others produced for

this sort of work, robustness and reliability, as well as sensitivity adequate for the normally very small currents to be handled, are essential features, and the successful fulfilment of these requirements is one of the great satisfactions of the hospital physicist.

The availability, since 1945, of a widening range of radioactive isotopes suitable for clinical use has raised many problems for the hospital physicist, especially in the fields of detection, dosemetry and safety, and appropriate techniques have had to be evolved for a variety of materials such as Phosphorus^{32}, Cobalt^{60}, Yttrium^{90}, Iodine^{131}, Tantalum^{182}, and Gold^{198} (in colloidal as well as metallic form). For accurate dosage not only has the rate of uptake by and the distribution throughout the various body tissues to be studied for any injected or ingested radioactive substance but careful record kept of excretion rates. Because large numbers of patients may be treated, or investigated by these means (over 1500 patients received Iodine^{131} tests or treatments last year in this hospital) much effort has been directed to devising procedures which can be carried out accurately and safely by technicians. In hospital physics as in every other field, the research method of to-day is the routine technique of to-morrow.

The increased use, since the war, of higher energy X-rays and of radioactive isotopes in other fields as well as in medicine has focused considerable attention on to radiation hazards and has emphasized the need to keep a constant check upon the doses being received by radiation workers. From 1949, therefore, we have been actively engaged in the problems of " monitoring " such people and the department not only did pioneer work in establishing the use of the photographic film as a reliable dosemeter for small amounts of radiation, but was the first to establish a complete service for a Hospital Region of the Ministry of Health. We are now continuously " monitoring " over 1500 radiation workers in the Manchester Hospitals Region. Much of this work can be safely handed over to technical staff but physicist supervision is still necessary especially in the organization of departmental surveys and in advising on the design, layout and protection of new departments. Keeping up to date with new regulations or recommendations especially on the use and disposal of radioactive materials in itself constitutes a considerable labour for any physicist at the present time.

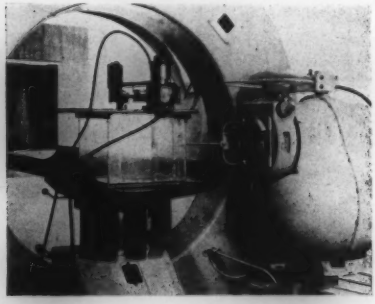

Fig. 2. *Equipment for the measurement of the distribution in water (which simulates a patient) of radiation from a 2000 curie Cobalt^{60} Beam Unit.*

An important departmental responsibility is the acceptance, testing and calibration of any new equipment acquired by the radiotherapy department. Therefore when the hospital acquired, in 1953, the first medical 20-million volt betratron in this country, and also one of the first 4-mV linear accelerators, an extensive programme of tests and measurements had to be undertaken on each machine. As a result, not only were the radiotherapists supplied with all the data and charts required, but it was realised that the high penetrating power of these beams made comparatively straightforward the production of special filters to modify the normal radiation distribution to one better adapted to certain types of treatment. To this end much work has been undertaken on the design of so-called " wedge " filters, the use of which makes many treatments more efficient and has been one of the greatest technical assets accruing from the use of high energy radiation.

Before any radiation that is markedly different from that previously used, is brought into service, it is essential to establish that the new radiation has effects comparable with those already known, or in what way the effects differ. Serious clinical use of the machines had to be preceded by extensive studies on chemical solutions and various biological systems in order to establish the so-called Relative Biological Efficiency between the new radiation and that already in use. This sort of problem typifies one of the roles of the department. On individual experiments radiation chemists, radiobiologists, cytogeneticists as well as radiotherapists were engaged, with physicists collaborating on each one as well as providing a unifying link for the whole.

Thus the clinical group is mainly engaged in the routine dosage control of radiation treatments, in collaboration with their medical colleagues, on improvements of technique, in the devising of new apparatus, in the maintenance and improvement of safety in working conditions and in investigations and original work which may lead to greater efficiency in treatment and a better understanding of the effects of radiation on human tissues.

At the same time the research group, cross fertilized by and cross fertilizing their clinical colleagues, are working on some of the more fundamental aspects of the subject, usually in conjunction with one of the other research groups. Two lines now under investigation may be mentioned as typical. The main theme of the research in the groups associated with the hospital is the acquiring of a better understanding of the action of radiation on living material. An important step in this direction would be the unravelling of the problem of how ionizing radiations act on simple solutions or even on water itself. Experiments are therefore in progress in which water and solutions of substances like ferrous sulphate are subjected to intense electron beams for very short time intervals, the reaction products and their decay then being studied by ultra-violet absorption spectroscopy.

Vital to all radiation experiments is a knowledge of the energy delivered to the irradiated object, and for many years this has been estimated via the ionization in air unit, the roëntgen. The shortcomings of this unit in some circumstances are recognized and, in 1953, a new unit, the rad (100 ergs per grm of irradiated material) was introduced. In many cases the dose in rads can still be estimated from ionization measurements but when more precision is required, absolute energy estimations have to be made. Therefore calorimetric studies of considerable refinement are being carried out to measure the energy delivered to solutions and other irradiated objects, and to compare these values with those arrived at from ionization measurements.

No survey of the work of the department would be complete without mention of its teaching responsibilities. In conjunction with the University of Manchester it prepares medical graduates for the physics examinations of the radiology diplomas, whilst it also provides physics lectures for those wishing to qualify as radiographers through the examinations of the Society of Radiographers. A total of some 150 hours of lectures annually to these groups as well as supporting practical classes demonstrates the importance attached to this work.

In many countries overseas radiotherapy services have only been established during the last few years, whilst in others the employment of physicists in established services is a recent innovation. There has been, in consequence, a considerable overseas demand for British physicists, or for British training for local physicists. This department, like many others in this country, has been pleased to receive for training, for periods extending up to one year, though more normally for a few months, physicists not only from the Commonwealth and the United States, but also from Holland, Poland, Brazil, Indonesia, Italy, Egypt, Thailand and Burma, to mention only the countries of origin of those coming during the last few years. Firmly believing that British radiotherapy and hospital physics to be among the best in the world, we are happy to undertake this work and fortunate to be able to enjoy so many and varied international contacts as a consequence.

A few years ago the description given above would have fitted the majority of hospital physics departments in this country. Now changes are taking place in many as more and more attention can be given to non-radiological medical specialities. However, one basic factor remains the same, the close collaboration between the physicist and medical man. It is this joint effort in the alleviation of suffering that makes hospital physics such a rewarding profession and a hospital physics department such a happy and stimulating place to work in.

The Training of the Industrial Physicist

A TWO-DAY conference on this subject was held in Birmingham on April 21 and 22. It was organized —and most efficiently organized—jointly by the Midland Branch and by the Education Group, and the thanks of all participants must go to the University and and to the College of Advanced Technology for so excellently looking after their physical comforts. Having at another conference earlier in the month queued fifty minutes for meat pie and chips, I particularly appreciated the quality of the meals and of the service.

One must visit Birmingham at regular intervals in order to appreciate the way the city is being transformed. I invariably get lost in the centre, where one-way streets never seem to point in the same direction for more than a few months at a time, and where familiar landmarks disappear overnight to be replaced by new ones, bigger and glossier than the ones they replace, but often of considerable architectural merit. My fixed star used to be New Street Station, until the Midland Region re-routed its trains to Snow Hill.

The University and the College of Technology too are in a state of transition, although it is more difficult here to find features of considerable architectural merit. At the University the physics department has expanded into a new building that completes one end of the flamboyant arc, at the centre of which Chamberlain's folly points skywards, while the department of theoretical physics will soon forsake its prefab for a bridge. The College of Technology in more pedestrian fashion inexorably marches round a vast rectangle, six storeys high, about two-thirds of which seem now complete. A phoenix rising from the dust of Gosta Green.

All this is relevant to the conference. Minds are influenced by bricks and mortar, glass and concrete, and where so much is changing and growing, here one's thoughts too may change and grow. Certainly some quite revolutionary suggestions came to be discussed as if they had been with us forever, while others, which were perhaps just a shade too revolutionary were allowed to be forgotten, but will, I hope, be put on permanent record on this report. Incidentally, for better or for worse, this is going to be a very personal report, since it will be liberally interlaced with the second thoughts that have come to me in the interviewing time. The conference was divided into four sessions, lasting half a day each, as follows :—

A. Problems of selection for Diploma in Technology and university degree.

A group of conference members in Fircroft College, Selly Oak

B. The university degree and Diploma in Technology compared as training for the industrial physicist.
C. Postgraduate training in physics.
D. Requirements of industry.

The title of the conference was perhaps unfortunate. As far as the Universities are concerned, they have never considered it their business to give a purely vocational training and, if the speakers had confined themselves strictly to their terms of reference, we might have heard no more from those from the universities than protestations that this was not what they were there for. It might be conjectured that staff in Colleges of Technology would take it to be their task to provide this very training which the universities refused or even scorned to provide, but it was in fact one of the most interesting moments of the conference when different representatives from Colleges of Technology clashed on the issue which can be crudely represented as "Education *v* Training". Largely, however, speakers implicitly modified the conference title to something like "The Education of the physicist with special reference to the needs of industry" and spoke accordingly. Nevertheless, it would have been helpful if the needs of industry had been known from the start, i.e. if the conference had started with session D. As it was, it became gradually clear that the views of the educationalists on the needs of industry often differed substantially from the industrialists' view, and not always in the expected direction, quite apart from the fact that industrialists themselves are unlikely to speak with a united voice on this subject.

It was apparent from the programme that the main speakers had been selected so as to represent the view points of the different interested parties, and it was therefore only rarely that any speaker attempted a critical appraisal of the whole subject. This was particularly so in session A. Mr. R. H. Knight started by outlining the procedure by which students are admitted to the University of Birmingham. The problem in his opinion was one of selection and he substantiated his point by revealing that when applications closed at the end of January last, there were 680 applications for about 75-80 places. However, he immediately added that only about 30% put Birmingham as their first choice and that most of the applicants had not yet qualified. Now several recent estimates put the multiplicity of applications per student at between 3·5 and 5, and since the physics department at Birmingham is surely one of the more desirable ones to apply to, this is in agreement with the figure of 30% first preferences. If we therefore add another 10% of second preferences, we obtain a figure of 270 serious applicants. Since most of these are not yet qualified, it is unlikely that the final number which will satisfy the stringent Faculty requirements can exceed 150-200. This is actually the number interviewed in the first place. The final task is therefore to reject one for each one accepted and since the bulk of this group must surely be of a uniform and fairly high standard, it is clear that whatever method of selection is employed, it is going to be difficult to go far wrong or to do much good. At any rate, it is known now that those rejected will with very few exceptions find places elsewhere. In the long run, according to Mr. Knight, about 22% of the entrants to the department failed to obtain an honours degree, although only 5% left without any kind of a degree.

It is necessary to digress here and to say something about failure rates at universities. These are variously defined as failure to obtain the qualification for which originally selected, or failure to obtain any qualification at all. It is often referred to as wastage, a very bad word indeed, as was pointed out by several speakers who pleaded for a closer approach to the American attitude, which is that it is better to have entered and failed than never to have entered at all. At any rate, however it is defined and whatever it is called, it is probable that it is not due to faulty selection at entry, but to faulty treatment after entry. We shall return to this later.

The second speaker was Dr. C. A. Hogarth of Brunel College of Technology. The problem of selection for the Diploma in Technology was quite different, since at present there was hardly any excess of applicants over places so that there was a temptation to fill courses with applicants who gave every indication of being on the wrong side of the border. Such temptation must in his opinion be sternly resisted. But must it ? Or is this not the place where we should give even the weak candidate his chance, as long as he does not keep out a better one. 'Tis better to have entered and failed. . . . An additional complication came from the industrial entry. Such candidates had often spent up to ten years in industry and qualified for entry through O.N.C. or a mixture of O.N.C. and A-levels, obtained the hard way by part-time study. How could they be compared to school leavers ? In practice it was found that some of the best students had come up this way. But will this continue, once the present reservoir, that has been built up over many years, has been emptied ? There are already indications that it will not.

Mr. F. Oldham, the headmaster of Hinckley Grammar School, took us back to school, as many a late speaker from the floor was to do with good effect. He gave an outline of the famous Leicestershire experiment, by which selection at 11 + has been abolished. This is not the place to discuss the merits of this scheme, which is hardly within the terms of reference of the conference, but the implications were clear. It was more important to avoid selection wherever possible, than to improve on selection procedures.

This point was re-inforced by Mr. J. A. Petch of the Joint Matriculation Board. All human characteristics are distributed continuously and, as he put it, the good God made most of us "fifty-percenters." He then gave some figures based on the J.M.B. examination. Physics was now the biggest A-level subject, having risen from 4,683 entries in 1951 to 7,326 in 1959. Of these, over 3,500 candidates were in the rather nondescript group who obtained between 33% and 50% in their marks. This meant that there were 200 candidates per percentage mark, or in fact rather more than 200 near the bottom end and rather less near the top end. The problem of any dividing line marking off success from failure was bound to be a rather arbitrary one under such conditions. He therefore pleaded for continuous selection at university. All students should have a common first year and only after that should they be divided between honours

and pass courses, with some transfer perhaps even possible during the second year. It is worth noting that this plea, which was supported by many of those present, is in complete contradiction with the policy of the Diploma in Technology and the degrees of London University.

Mr. Petch then speculated on possible changes in A-level examinations. He felt that the present examination was quite able to serve as both a school-leaving qualification and as a university entrance test, but left doubts in the mind of at least one of his listeners. Is there not an essential difference between the type of examination that tests past achievements and one that tries to predict future ones. As Mr. Petch himself said, an examination is like a mile-stone. It tells you where you have got, but not how you got there, how long you took over it or whether and when you will reach the next mile-stone. This is certainly true of the present A-level examinations, but is it a law of nature that no examination can be more than such a mile-stone ? Lastly, Mr. Petch promised changes in the examination in English. " O-level English at 16," he thundered, " is no criterion of literacy in a B.Sc. and can be one of illiteracy in a Ph.D."

The last speaker of session A was Mr. R. Lemoine of Smith and Nephler Ltd. Contrary to the opinions expressed by the other speakers, he claimed that examinations could have considerable prediction value—provided they were scientifically designed diagnostic tests. These could then be supported by personality tests, interviews and group selection methods. Such methods are believed to have greatly aided officer selection in the last war, and it is a pity that no university department of education seems to have made a thorough study of them and of their relevance to university selection. It would surely not be difficult to give such a test to a group of university entrants that had already been selected by orthodox methods and see how the results of the test compared with examination results some years later. This would at least give half the answer ; to deal with those that had been rejected by orthodox methods would of course be more difficult. But as most of them find places at other universities, it would not be too difficult.

Mr. Lemoine in an aside remarked that, with the exception of Rol and word association tests, personality tests are at present suspect. Readers of Whyte's *Organization Man* will consider this the understatement of the conference.

Discussion ranged widely, but the most important point that emerged was that there was at present no substantial reservoir of able students that did not manage to find a place. As a consequence Diploma in Technology courses, being new and lacking the prestige that a degree confers, might find themselves catering largely for those that had just failed to get into a degree course. This had undoubtedly happened in the first years after the courses had been established, but there were now some encouraging signs that the Diploma in Technology courses were establishing themselves in their own right. The conference went in the usual manner over the apparently insoluble problem of attracting more girls to the physical sciences in order to increase the reservoir of able students, but Mr. Petch finally reassured members that the general position was not as bad as it seemed. At present a trough in the birthrate had reached the 18 year olds, but in 1964 the bulge would hit the universities. Also there was a small but encouraging increase in the percentage of girls taking A-level physics.

One problem hardly got a mention—that of selection for Diploma in Technology *or* university degree. Mr. Oldham thought that the boy who already at 18 knows that he wants to enter industry should take the Diploma course, but other speakers who did not touch on the subject presumably thought that it could not be discussed without a knowledge of the conclusions reached in the next session. It is fair to sum up this session by saying that whatever course a student entered for, what he needed was—in Mr. Knight's words—enthusiasm, real ability in physics and mathematics, and an enquiring mind which would " delight in simple things." But then, anyone who had all these would select himself.

In his introductory talk to session B, Dr. J. H. Davis of the Birmingham College of Advanced Technology presented the view that the essential feature of the Diploma in Technology course is that it is a direct training for industry, which the degree course is not. The aim of the Diploma was the production of technologists with knowledge of particular fields of science and of problems arising in industry, while that of the degree was to produce a person who might go into research, administration or teaching as well as into industry. The Diploma syllabus would therefore be more factual and include specific technologies, while the degree syllabus would be more basic and include fundamental subjects, which might be valuable as a long-term policy. In the way the holder of the Diploma (diplomate ?) would be much more immediately useful than the graduate, and that was what industry required. Later in the discussion Dr. Davis's exposition was strongly challenged by his colleagues from Brunel and Battersea, who maintained that the Diploma must allow the holder to be quite as versatile and quite as free in his choice of profession as was the graduate, and that there was no essential difference between the courses. Both provided an education, and the difference was one of detail. In his final summing up Dr. Davis seemed to come closer to this view than to the one he had expressed previously.

Another point raised by Dr. Davis found more general acclaim. This was the fact that many graduates knew little about and thought less of industry when they first entered it and found it very difficult to get on with the men at the bench and on the floor. This was put down to the atmosphere in the universities which puts pure research first and the rest nowhere. Undoubtedly this atmosphere is absent in the Colleges of Technology and Dr. Davis thought further that the four six-monthly contacts which students had with industry and the men in it, starting at the age of 18, would greatly help them in appreciating the problems of industry and adapting themselves to them. Unfortunately it is probable that the problem is a much more serious one and is deeply rooted in the structure of English society. Thanks to the efforts of C. P. Snow and others it may no longer be most gentlemanly of all to know no science at all, but it is certainly true that it is more gentlemanly to discover than

to invent, and that to manufacture is less gentlemanly than either. And if you must have technologists, then for heaven's sake don't give them degrees. They will be thinking themselves as good as university men next.

Dr. Davis lastly referred to liberal studies. The subject is one to which much lip-service is paid and it was good to hear Dr. Davis wonder just how broadly educated were the students in our universities. Was this really a problem that was so exclusively one for the technologists ? To the usual visitor from Mars it must surely seem strange that we alone of all people (and this excludes the Scots) have a school system that forces a boy to become so one-sided at 16 that by the time he is 19 he is either illiterate or innumerate (Crowther's phrase), and that we then try to drag him back into the middle by rather feeble efforts in the university, which are so obviously not meant to be taken seriously, that even the dimmest student cannot fail to notice this and draw the obvious conclusions. I trust that the Education group will soon turn its attention to this problem, discussed so ably by Dr. Peterson in his report on the "Arts and Science Sides in the Sixth Form," which came out in the week before the conference.

We next heard from Mr. E. R. L. Lewis of the English Electric Co. Ltd., who in an almost off-hand manner produced a few bombshells which somehow failed to explode in the conference. However, they are there and I would like to act as marker for any future bomb disposal squad that likes to tackle the job. He started by wondering whether just because a sandwich course had been considered the right thing for engineers, it was also necessarily a good thing for physicists. This led him to muse on what was required of physicists in industry and he came up with the conclusion that what was wanted was not the man with detailed knowledge in a specialized field, but, on the contrary, the man who was always keen to go into a new field. In fact he deplored the overcrowding of the degree course, a situation which is no easier in the Diploma course, where room must be found for half a dozen ancillary subjects, such as workshop practice and management studies. He somewhat spoiled the effect of these remarks by saying later on that one of the potential advantages of the Diploma course lay in its close co-operation between industry and college, which made it possible to design a syllabus to fit the needs of industry. Here surely " detailed knowledge in a specialized field " is coming in with a vengeance. Or dare I suggest that here, just for a moment, we were permitted a glimpse of the cloven hoof ? Is the Diploma to be for the lower echelons that deal with the problems in hand, while the difficult ones that require flexibility of mind are left to the clever graduates in the back room.

Professor M. R. Gavin, University College of Bangor, firmly disagreed with Dr. Davis that the aims and methods of Diploma and degree courses should differ in essentials. The principles of physics were acquired largely at A-level—here his audience gave an audible gasp—and it was the task of the next three years to enlarge on these and, rather less importantly, to add certain special subjects. These, however, must always be used to teach basic principles and not treated as ends in themselves. The outstanding difference between the courses lay in the sandwich nature of the Diploma course and the industrial period ought to be of great value. Some of the difficulties associated with the industrial period were later picked out by Dr. Davis when he referred to the highly specialized nature of much of the manufacturing industry around Birmingham which made it difficult to arrange the varied training programme that ought to be of the essence of the industrial period.

Professor Gavin went on to describe the course in applied physics and electronic engineering in his department. This course had a common core, but allowed the student in the second and third year to specialize somewhat either toward physics or toward engineering. It showed that in the universities, too, experiments in technological education are not unknown. Finally, he made a strong plea that no College of Technology should enter students for the London external degree. With its almost inevitable beat-the-examiner attitude, such a course could not possibly give any real education. However, as was later pointed out, there are other reasons for carrying on with the London external degree. With the exception of the London Colleges of Technology where students are able to enter for internal postgraduate degrees of the university, no Colleges of Technology can enter students for higher degrees unless they hold a first degree from London University. In that case they can take a higher degree externally and this is therefore the only way by which the provincial Colleges of Technology can attract students for postgraduate research. The M.C.T. is clearly not fulfilling this purpose at present and it is quite clear that unless this situation changes rapidly, one of the most valuable aspects of research work will become impossible in these colleges.

In the discussion a most important contribution was made by Mr. H. W. French (Ministry of Education). He first reminded the conference that the Ministry had from the start been in favour of five-year sandwich or four-year full-time Diploma courses and that much of the congestion in these courses of which speakers had complained could be avoided if the courses ran over five years instead of the more usual four. Furthermore, he had noticed that the Diploma syllabuses in electrical engineering—he had no detailed knowledge of physics syllabuses—had in the past few years come closer to most degree syllabuses. While initially Diploma syllabuses had contained a number of specialized technologies, it had not been found possible to keep these in without skimping the fundamentals of the subject and they had in consequence mostly disappeared. The difference between degree and Diploma lay in the industrial training, and he wanted to stress that it had to be training and not just experience.

This was cheering news for those who have believed that there is not very much wrong with a good degree course and that radical departures from it would not lead to any improvement. It raises the issue whether there should in fact be a problem of selection for Diploma *or* degree at 18. If the courses are so similar, then surely for one or even two years they could be the same. In the final year there would be options, for instance, advanced electronics as against theory of relativity, and the project too could range from the ultra-pure to the

highly practical. Such courses, with the industrial experience (not training) confined to the long vacations, are given, for instance, in the Technische Hochschule, Aachen and in the Carnegie Institute of Technology. The sandwich nature of most of the present Diploma courses and the inability of Colleges of Advanced Technology to award degrees make it difficult to carry through such a scheme in this country at present, but it is an educational experiment that is well worth trying. It would of course be quite possible to include a full year's industrial training in the scheme.

Session C was based on the joint report of the Institute of Physics and the Physical Society on the postgraduate training of physicists in British Universities. The report contained some truths which it was thought that the universities might find difficult to swallow, and these had hit the headlines of the Press. But it must be said at the outset that at least since the day four years ago, when Professor Bethe left the Cavendish Laboratory at the end of a year's stay with the remark that in England theoreticians cannot tie their shoelaces and experimentalists cannot integrate, many physics departments all over the country have looked into the postgraduate training of their students and some have begun to do something about improving it. The most generally held conclusion is that to avoid over-specialization attendance at postgraduate lecture courses covering a wide field of largely theoretical physics is essential and that an examination at the end of such courses is desirable.

Professor J. G. Wilson (Leeds) introduced the report, and there is no need to summarize his summary here. He thought that the introduction of these additional lectures into a fourth undergraduate year would be a mistake, since they would constitute very heavy going for the weaker half of an honours class. In a postgraduate course, with numbers of students smaller and quality higher, much more rapid progress could be made and it might not be necessary to lengthen the postgraduate course beyond its customary three years to accommodate such lecture courses. The main criticism from industry had been that holders of a Ph.D. frequently lacked originality, flexibility and an adequate background in physics. Few would deny that there was a great deal of truth in this, but he was sure that similar criticisms would apply in other subjects, and that the standing of the Ph.D. in physics was at least as high as in other fields. The fault lay in the situation by which any student who got to the point of handing in his thesis was virtually assured of his degree. In the discussion it was later suggested that this difficulty could be overcome if an M.Sc. could be awarded to a candidate whose thesis or performance in the oral examination did not come up to Ph.D. standard. Another possibility was to award an exceptionally good Ph.D. *summa cum laude*.

Mr. M. P. Rooksby (Research Laboratories, G.E.C.) stressed that little research of a fundamental nature was carried on in industry, but that pure research was not the only good activity. He suggested that Ph.D. students should spend a period in industry, i.e. take a kind of sandwich Ph.D. course, but this was later strongly opposed by Dr. Schoenberg on the grounds that once a man had his mind on a research project, it ought not to be taken off it. At any rate, as was pointed out, there was the M.C.T. to cater for the man with one foot in industry and the other in the university. Few of the audience seemed to know what these magic letters meant and those that knew had grave doubts as to the practicability of this award, at least as far as physics was concerned. Physics research in industry was generally so different from that in a university that it would hardly ever be possible to carry it out under the combined supervision of the two.

Dr. D. Schoenberg (University of Cambridge) brought the authority of the Cavendish Laboratory into the discussion. While he agreed that postgraduate teaching, particularly in quantum mechanics, statistical mechanics and mathematical methods, was needed, he did not think it could be fitted into the usual three years, so that the Ph.D. course would have to stretch over four years. Nevertheless, the most important experience for the student was the close contact with outstanding individuals in his field, since this developed his intuition and instinct. A Ph.D. should therefore only be attempted in a stimulating research school. At this point some of us, aware of our shortcomings, shifted uneasily in our chairs.

Dr. Schoenberg then turned to the estimate that industry was putting on the Ph.D. and wondered whether any of the best were going into industry. There was room for "wild men" in industrial research, but few firms were prepared to allow a good man sufficient freedom and this discouraged the best from considering industry as a career. The situation was somewhat better in the United States where a few firms such as General Electric and Bell Telephone Laboratories had realized that giving complete freedom to the best men was exceedingly profitable commercially. He instanced the case of an expert on magnetism at General Electric who had developed an interest in biophysics. So the firm bought him an electron microscope. No English firm could compete with that, of course, but more could be done. At present only establishments such as Harwell and Malvern provided real freedom for some of their scientists.

In the discussion Dr. Hogarth suggested that students should spend some years in industry between their B.Sc. and the beginning of their Ph.D. courses. This was supported by Mr. Warren, but opposed by Dr. Bosley who had tried it and found it difficult. One forgot too much and one's mind got on the wrong lines for pure research.

Mr. Warren also felt that the report had not been objective to the faults of the industry and this point was taken up, perhaps a little too strongly, by the present writer. This brought upon him the wrath of Mr. Clarke who wanted it to be quite clearly understood that the witnesses from industry had not been tycoons who had risen without scientific training to the director's chair, but practising scientists, many of whom had spent many years in the universities. There was no doubt about it—the criticism of the products of our present Ph.D. courses was sound and need heeding.

Had I had any doubts about this before, Mr. Clarke's remarks would certainly have dispelled them. What I doubt is that industry is making enough use and the best use of the best. On the Sunday after this conference, it

was stated in the *Observer* that 70% of the country's industrial research and development is in three industries —aircraft, electrical engineering and chemicals—while there are virtually no research workers in, for instance, ship-building and the machine-tool industry. Two days later the scientific correspondent of the *Guardian* made similar points in an article on " Research and Society." When therefore the report on postgraduate training says that " before the second world war very few industrial firms saw reason to employ physics graduates," we should view with some suspicion that now " industry would prefer that only a small proportion of its recruits had had research training for a Ph.D."

There seemed little left to discuss in session D, but Mr. Milbourn and Mr. Bastick proved that this was not so to such an extent that their contributions must stand on their own and cannot be included in this report, which at any rate is now quite long enough.

A very good conference was had by all.

L. R. B. Elton.

Notes and News

Summer vacation

Members are asked to note that the headquarters building at 47 Belgrave Square will close at 5 p.m. on Friday, July 29, and reopen at 9 a.m. on Wednesday, August 3.

Conference on diamond physics

The Physical Society arranged a conference on diamond physics to be held at the J. J. Thomson Laboratory of the University of Reading on September 22 and 23 next. The conference will, of course, proceed exactly as planned but under the amalgamated body " The Institute of Physics and The Physical Society." The papers will deal with the physics of diamond and silicon carbide under the following sections: dissolution, reactivity and growth; mechanical properties; impurities and defects; intrinsic properties.

Further details and application forms can be obtained from Dr. A. C. Stickland, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

The Advancement of Science

We are glad to welcome the British Association's *The Advancement of Science* in its new and attractive format. As Sir George Thomson writes in the foreword, " The proportion of educated people with a reasonable appreciation of contemporary science has hardly risen in the last century and may even have fallen." It is in an attempt to do something more to remedy this situation that the Council of the Association has agreed upon a new editorial policy. The journal (this issue being of 90 pages) will be published six times a year ; the subscription rate is 40s. a year (including postage) and single copies are 7s. 6d. each plus 7d. postage.

Biological Engineering Society

A new Society, The Biological Engineering Society, has been formed to bring together members of different disciplines, from hospitals, research institutes and industry, to further the applications of engineering to biological and medical problems.

Dr. R. Woolmer, Professor of Anaesthesia at the Royal College of Surgeons, is the first President. The Acting Secretary is Dr. A. Nightingale, F.Inst.P., Physics Laboratory, St. Thomas's Hospital, S.E.1.

The Annual Dinner

The Annual Dinner of the Institute was held at the Park Lane Hotel, London, on Tuesday, May 3, and was attended by about 327 members and guests. They were received by the President and his daughter, Miss Rose Thomson.

The Institute's official guests, most of whom were accompanied by their ladies, were Sir Roger Makins (*Chairman, United Kingdom Atomic Energy Authority*), Dame Mary Smieton (*Permanent Secretary, Ministry of Education*), Monsieur H. de Leiris (*Président, Société Française de Métallurgie*), Mr. J. A. Ratcliffe (*President, Physical Society*), Dr. T. H. Osgood (*Scientific Attaché, American Embassy*), Dr. G. B. B. M. Sutherland (*Director, National Physical Laboratory*), Dr. F. W. G. White (*Chairman, C.S.I.R.O., Australia; Past President, Australian Branch of the Institute*),

The President and Miss Rose Thomson.

Left to right: Mr. W. K. Brasher, Mrs. Brasher, Mrs. Humphreys and Mr. O. W. Humphreys (Past President).

Professor H. C. Webster (*Immediate Past President, Australian Branch of the Institute*), Mr. E. LeQ. Herbert (*President, Royal Institute of Chemistry*), Sir Willis Jackson (*President, Institution of Electrical Engineers*), Dr. A. C. Monkhouse (*President, Institute of Fuel*), Professor A. J. Murphy (*President, Institution of Metallurgists*), Dr. A. S. Parkes (*President, Institute of Biology*), Professor O. A. Saunders (*President, Institution of Mechanical Engineers*), Monsieur E. J. Solvay (*President, Society of Chemical Industry*), Mr. A. J. V. Gale (*Editor, "Nature"*), Mr. W. K. Brasher (*Secretary, Institution of Electrical Engineers*), Mr. D. J. B. Copp (*Secretary, Institute of Biology*), Dr. H. J. T. Ellingham (*Secretary, Royal Institute of Chemistry*), Lt-Col. F. J. Griffin (*Secretary, Society of Chemical Industry*), Mr. R. G. S. Ludlam (*Secretary, Institution of Metallurgists*), Dr. D. C. Martin (*Secretary, The Royal Society*), Mr. R. W. Reynolds-Davies (*Secretary, Institute of Fuel*) and Mr. K. E. Kay (*The Institute's Advisory Surveyor*).

The toast of The Institute of Physics was proposed by Sir Roger Makins, and the President replied.

Dr. C. Sykes (*Past President*) proposed the toast of the guests, to which replies were made by Mr. Ratcliffe and Monsieur de Leiris.

Sir Roger and Lady Makins with (right) Dr. F. A. Vick.

Sir Lawrence Bragg (Past President) and Lady Bragg being received.

Sir George and Miss Thomson with Mr. and Mrs. E. R. Davies.

Left to right: Dr. J. M. Dodds, Mrs. Sillars, Mrs. Dodds and Dr. R. W. Sillars.

Dame Lady Smieton being received.

Mr. and Mrs. L. Rotherham with Dr. F. A. Vick.

Professor H. Lipson and Mme. Weill.

Mrs. Coales, Mr. J. F. Coales and Miss M. K. B. Day.

Letters to the Editor

The Value of a Physics Degree

The trouble with human beings, from the point of view of educating them, is that they learn most readily and are in greatest need of learning at a time when they are least able to judge what is most useful for them to learn. As a result our educational system has evolved into a pattern which allows an increasing choice of subject-matter to the student as he becomes more knowledgeable and more mature. At first he learns almost to exclusion that which he is told to learn, and only later may he pick out and follow his own course.

So long as the field of physics continues to expand, controversy will continue to rage over whether this or that subject should or should not be included in the honours course. Which opinion wins, however, will remain in one sense relatively unimportant, for the first degree will forever be that which it has always been—a grounding in the subject. The first degree is the last generally recognized stage in the process of learning what one is told to learn, while at the same time it is to be hoped that it is by no means the first stage in the process of seeking out one's own knowledge. It is therefore of no importance whatever that Smith graduates without enough electronics for his new job, or that Jones must learn more mathematics, or Brown finds out about stress analysis. There is one degree in physics, and a million paths to follow after taking it: to suggest that the physics degree should be a complete training for every undergraduate's subsequent life is to forget the place that degree holds in the scheme of a physicist's education. What is important to Smith, Jones, and Brown when they graduate is that they are aware of the whole structure and some of the details of their subject, that they have developed methods of thought which enable them to tackle new problems, and that they have learned how to learn for themselves.

Mr. Simmons' question[1] is, to my mind, no more than a plea for greater specialization within the honours school. We have been through all this before, but the form of the question as it is posed by Mr. Simmons prompts yet another argument against it, which I put as a question also. How many physicists can honestly say that they knew in their undergraduate days just where life was going to lead them in the future ? How many could have specialized in the field which was their choice at the end of their second year, or at the end of their first, and not have had some later regrets ? Professor Klemperer once remarked to me that it was his experience that a good physicist could do anything: If we try to specialize any sooner than we already do, this statement will quickly become untrue, and I am convinced that the progress of physics would at the same time slow down.

R. W. Goodley (*Associate*).
c/o Iraq Petroleum Co. Ltd.,
P.O. Box No. 1,
Kirkuk, Iraq.

1. *Bulletin*, April, 1960, p.122.

Final Year Project Work in the Applied Physics Diploma in Technology

We read with interest Dr. C. A. Hogarth's article on "Final Year Project Work in the Applied Physics Diploma in Technology" which was published in your March issue. We feel that more detailed consideration should be given to the precise purpose of this project work.

In our opinion, the project serves two purposes. First, it gives the student experience in carrying out a minor investigation, largely on his own initiative; secondly, it enables his supervisor at college to assess, as can be done in no other way, the student's originality and ability to carry out such an investigation. In the case of a student reading for a degree it may well be that the first of these is the most important since, apart from a few weeks as a vacation student in industry, he has no other opportunity to gain experience of this type. The situation is markedly different for a student taking the Diploma in Technology on a sandwich basis since he spends four six-month periods in industry in each of which he is likely to be engaged on research or development work appropriate to his stage in the course. As Dr. Hogarth points out, the time which a college can allocate to the project is equivalent only to four or five weeks of full-time experimental work, apart from the time which the students spend in planning their project before returning to college and that spent in preparing their report after returning to industry. We therefore believe that the main purpose of the project work in a Dip.Tech. course must necessarily be the assessment of the student's capabilities in this field.

It seems to us that, if a fair and realistic assessment is to be made, all the students should be given a project related to their particular interest, but not one in which they have been engaged for a considerable time in industry. Otherwise the college supervisor will find it difficult to assess the student's own contribution to the work; moreover, it might well involve some students in carrying out work of postgraduate standard, while others are able to work on a project more appropriate to an undergraduate course. It is true that our method of selecting projects is unlikely to lead to published work arising from the project, but this should surely not be the object of undergraduate teaching.

In conclusion, we wonder what significance should be attached to Dr. Hogarth's statement that the project marks did not differ by more than a few per cent from the results of the theoretical examinations. If this was found to be true for a more representative selection of students it would seem that either the project assessment, or the written examination, is unnecessary.

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Reviews of Books

PLASMA PHYSICS

By J. G. Linhart

Amsterdam: North Holland Publishing Company. Pp. xi + 278. Price 50s.

The literature on plasma physics, currently interpreted mainly as work on controlled thermonuclear reactions, is steadily growing, but even so if we ignore the flow of conference reports which are sometimes composed of little more than undigested communications on work in hand, there are still very few books dealing with high temperature electrical discharges as distinct from, say, astrophysical manifestations. The author of the present work, who is well known for his contributions in the C.T.R. field, has given in his book an interesting presentation of the complementary approaches of (1) individual particle motion, and (2) a fluid description of a plasma in relation to the study of high temperature discharges. These treatments occupy two long chapters followed by others on equilibrium configurations and waves and instabilities in a plasma. This is followed in turn by a disappointingly short chapter on shock waves in a plasma, a matter of almost universal importance in this field. Then collision and relaxation processes are discussed and a further comprehensive chapter deals with the basic theory (nuclear cross sections, etc.) of controlled fusion and includes an intriguing speculation on the method of operation of an H bomb. In this chapter also there is a treatment of confinement problems and the energy balance. The final chapter is on other applications of the basic theory given in the early part of the book, i.e. the generation of high frequency electromagnetic waves, the direct conversion from chemical to electrical energy, applications to particle accelerators (a field in which Dr. Linhart is particularly well known), rocket propulsion and storage.

The book can be highly recommended.

J. D. Craggs.

THE CONCEPTUAL FOUNDATIONS OF THE STATISTICAL APPROACH IN MECHANICS

By Paul and Tatiana Ehrenfest, translated by Michael J. Moravcsik

Ithaca: Cornell University Press; London: Oxford University Press. Pp. xvi + 114. Price 24s.

This little book is a long overdue translation of the famous article on the conceptual foundations of statistical mechanics which the Ehrenfests wrote for the Encyklopädie der mathematischen Wissenschaften of 1912. The book falls into three parts: Firstly, a beautifully clear account of the assumptions underlying the original kinetic approach of Maxwell and Boltzmann—this leads naturally to the paradoxes of Loschmidt and Zermelo; secondly, as the centre piece of the book, a concise and systematic exposition of the basis of the ensemble formulation or—as the Ehrenfests put it—of the statistical kinetics of the gas *model* rather than of the gas *molecule*. The meaning and interpretation of the H-theorem is analysed most penetratingly to reveal the now familiar, but always exciting, resolution of the classical paradoxes. The third and last section of the book is essentially a critique of Gibbs' program for the general foundation of statistical mechanics. For the less specialized reader this section although a model of analytic clarity lacks somewhat in impact and cohesion. Only here does one remember that in 1913 quantum theory was in its infancy, Planck's radiation theory and Einstein's application of it to specific heats being as yet unassimilated by the body of mechanics. In all, however, one must agree with Professor Kac and Professor Uhlenbeck when they say, in their foreword to the book, " In spite of the passage of time it has lost little of its scientific and didactic value and no serious student of statistical mechanics can afford to remain ignorant of this great work."

The translator, Dr. Moravcsik, is clearly at home in statistical mechanics and his translation is competent and most acceptable. One might disagree with his judgment only in his retention of a few clumsy German constructions such as " Zermelo's *Wiederkehreinwand* " in place of the customary " Zermelo's paradox." It is difficult to believe that the former really saves " nuances of meaning " for anyone but German speaking readers. One doubts also the editorial wisdom of collecting all the many footnotes—averaging three a page—at the end of the book. Some are simply references but many contain profound and apposite comments and it is a nuisance to have to hunt for these a hundred pages further on ! The book is well produced and reasonably priced.

Michael E. Fisher.

IONIZATION PHENOMENA IN GASES

By Gordon Francis

London: Butterworths Scientific Publications. Pp. vii + 300. Price 60s.

The author makes it clear in his introduction that he has not attempted to follow the usual treatment given in books on ionization in gases and which normally follow a fairly regular and standard pattern, starting with single collision processes and working up to the glories of glows, arcs and sparks via a description of statistical processes in swarms. Dr. Francis in the present work has chosen in a most interesting way to provide a very brief introduction to fundamental matters and then to proceed with fairly detailed descriptions of rather special subjects in the field of gaseous discharges. His choice of subject matter has been clearly partly dictated by his own special contributions and interests and is a most interesting one in that it deals with matters seldom treated in books and which should nevertheless be common knowledge amongst discharge scientists.

In this way Dr. Francis deals at some length with the Similarity Principle, a.c. and h.f. discharges, ionization and excitation in the upper atmosphere, high current

discharges and thermonuclear effects and finally plasma oscillations and waves. This last chapter is of particular interest because I feel that plasma oscillations are probably more important than is often realized in quite a wide range of discharge conditions and similarly the implications of the Similarity Theory are often not realized. Thus I find the application of the latter to fully ionized gases a most interesting part of the book.

On a.c. and h.f. discharges the account is, as one would expect from the author's own work, authoritative and describes a picture delightfully simple to appreciate now that it has been painted. Due recognition is made of the earlier work of Gill and von Engel. Perhaps figures 4.11–4.12 are a little luxurious but " why should a man sit esurient at his own table ? " Work at higher frequencies, e.g. that of Biondi and Brown, Prowse and others, is also included here. The chapter on the upper atmosphere gives a clear elementary exposition and describes such matters as probing techniques, the Chapman theory, ionization and balance processes and briefly (if a little breathlessly) the van Allen radiation belt. Then follows a complete treatment of high current pinch phenomena, starting in an elementary way and then elaborations. The phenomena of collapse, transient pinches and skin effect are treated and an elementary theory of C.T.R. work is given. There are interesting examples of possible techniques in this field. Finally there is a chapter on plasma oscillations to which reference has been made above. This is fairly tough going but, as I have inferred, its importance may not always be fully realized.

There is no doubt that undergraduate students and those beginning research in this field should find the work most interesting and stimulating and it is to be highly recommended.

J. D. Craggs.

CRYOPHYSICS

By K. Mendelssohn

New York: Interscience Publishers, Inc. Pp. viii + 183. Price: Cloth 31s. 6d. Paper 17s. 6d.

This book provides a short but comprehensive account of low temperature physics. The selection of material is similar to that used by Dr. Mendelssohn in lectures to Honours Course students at Oxford and to research students intending to take up low temperature work. The book also provides a general survey of low temperature physics for those interested but not necessarily engaged in this field.

In successive chapters the author surveys gas liquefaction, magnetic cooling, thermometry, specific heats, magnetism, transport phenomena, superconductivity, and the helium problem.

Reference is made to specialized books and articles but not to individual papers. Thus the dozen references at the end of chapter 1 cover the entire field of helium liquefiers, magnetic cooling and gas liquefaction, also rectification. Chapter 2 on thermometry explains how in the cryogenic range of gas cooling the equation of state of the gas and in the magnetic range that of the paramagnetic substance provide the bases for primary thermometers, secondary thermometers are also dealt with. Chapter 3 is devoted to specific heats. One would have liked a more detailed discussion. For example after stating Einstein's fundamental contribution when he treated the solid as a system of simple harmonic oscillators of the same frequency, Nernst and Lindemann's expirical suggestion of two frequencies one half the other, Debye's frequency spectrum where the solid is treated as a continuum in which the thermal vibrations are represented by all possible modes of standing waves in the body ranging from acoustic vibrations up to a limiting frequency and finally the frequency spectra deduced by Blackman and others who have made detailed analysis of the modes of vibration to be expected in a crystal. To have a clear understanding of the work of Debye, Blackman and others the reader will need to consult the authorities quoted. In this chapter there is a brief description of calorimeters for the determination of specific heats at low temperatures.

Chapter 4 is a brief survey of the advances in the last decades in the study of the magnetic properties of matter. It includes an interesting account of the de Hass-van Alphen effect.

Chapter 5 discusses transport phenomena particularly electrical and thermal conductivity in metals and dielectrics. A vast amount of information is reviewed in this chapter.

Chapter 6 deals with superconductivity discovered nearly 50 years ago and is of especial interest. Nineteen references are given to the literature.

Chapter 7 is entitled " The helium problem," as the author points out the significance of helium in low temperature physics was at first due to the fact that it is the substance with the lowest critical constants and that it extended the range of temperature attainable by gas liquefaction to within less than one degree of absolute zero. The unusual behaviour by which liquid helium differs from all other liquids has since, however overshadowed its importance as a cryogenic working substance. In 32 pages of text the author surveys the field and supports it by 26 references. The last chapter of the book is devoted to a number of interesting problems in low temperature physics which do not fit easily into any of the main subjects discussed in preceding chapters.

Ezer Griffiths.

INTRODUCTION TO MATRIX ANALYSIS

By Richard Bellman

London: McGraw-Hill Publishing Co. Ltd. Pp. xx + 328. Price 77s. 6d.

This volume is the first of a projected series devoted to an exposition of the results and methods of modern matrix theory, and is intended to acquaint the reader with the fundamental concepts.

Starting from a consideration of maxima and minima of functions of two and more variables leads on to the consideration of quadratic forms and symmetrical matrices, the theory of which is developed in the first few chapters. Unsymmetrical and rectangular matrices are then introduced and the general theory is further developed with functions of matrices, variational

properties of characteristic roots and so on, the emphasis still tending to be on square matrices.

We then have four chapters on differential equations and stability theory, and finally three on positive matrices related to probability theory, stochastic processes and mathematical economics. These later sections are still primarily concerned with the properties of matrices; differential equations, probability theory, etc., merely providing the motivation for the particular types of results sought, and no very specialized knowledge of these fields is demanded.

The author tries to introduce at each stage only those new symbols and ideas which are necessary for the problem at hand ; and the, to the author, apparently, rather wearisome results concerning solutions of linear systems of equations and the rank of the matrix are relegated to an appendix.

One feels that there is a lack of consistency when in the preface the author confesses that some chapters are rather more introductory than others, and urges the beginner to read chapters 1 to 5 and then jump to 10 and 11 and 14 and 16. This he thinks would cover a semester course at undergraduate senior, or first year graduate level.

This suggests that the book might have been better planned in two parts to cover two separate years of a two-year course. This would have made it easier to recommend to appropriate groups of students. As it is, it is likely to be a library book which students take out only for occasional reference.

This would be a great pity for the book is written by a mathematician who has contributed considerably to recent developments and whose enthusiasm and insight illuminate the subject continually. The book is full of examples and each chapter is followed by a section of anything from one to several pages which is headed " Bibliography " but which is really a sort of running commentary by the author on the subject matter of the chapter which includes incidental references to other texts and original papers.

This is altogether a stimulating book.

A. W. Gillies.

FOURIER TRANSFORMS AND X-RAY DIFFRACTION

By H. Lipson and C. A. Taylor

London: G. Bell & Sons Ltd. Pp. viii + 76. Price 18s. 6d.

Although X-ray crystallographic techniques are now used in a wide variety of contexts and attract recruits with all sorts of backgrounds, yet it remains as true to-day as it was in 1913 that both the experimental techniques and the associated principles belong to physics. This slim monograph is intended primarily for the advanced student or research recruit, whatever his background, and aims to give him a good insight into both diffraction theory and the relations between a pattern in real space and its Fourier transform in reciprocal space.

These topics have long been recognized as fundamental to all understanding and progress in X-ray structure analysis, for all the information as to the structure that the X-ray analyst usually possesses lies in the set of values of the modulus of the Fourier transform sampled at regular intervals. His ability to interpret this depends on the extent to which he can recognize the implications of both the coarser and the finer detail in the transform, and, so long as this detailed knowledge had to be acquired by calculation, progress was slow.

It is largely to the two authors of this book and their colleagues that we are indebted for the optical diffractometer and the recent rapid accumulation of interpretive insight. Now they have paused, however, not merely to summarize (and many a busy research worker will be grateful for this), but to demonstrate how quickly and directly the optical approach enables one to feel almost equally at home in either real or reciprocal space—a facility whose importance can hardly be exaggerated. Introduced this way, X-ray diffraction is a straightforward extension of a familiar physical process: Fourier transforms are no longer mathematical notions; they appear as photographs to be " read " : processes such as convolution lose their semblance of artificiality; they are an inevitable consequence of the regular repetition or modulation of a pattern. The first five chapters deal with these topics, the mathematics always flowing out of the physical phenomena, rather than the reverse, and chapter six deals briefly with the possible ways of using the observed data for the reverse transformation. Chapter 7 deals with a variety of applications taken from both ordered and disordered structures, and is indicative of the powers of this method. The rapidity with which the optical diffractometer furnishes transforms has virtually allowed us to watch the effects of ordering and transformation processes taking place. It is hardly conceivable that a similar " feel for the problem " could be acquired in any other way. No less stimulating are the comments on the transform way of looking at various well-known features of the weighted reciprocal lattice, such as are used in intensity statistics and direct methods of structure solution. There are three illustrative appendices that will repay study, and the book contains a useful selected bibliography.

Teachers and students alike will welcome this book, for, provided the student has a reasonable acquaintance with the optical diffraction grating, he should be able to master this as private reading. It deals, of course, with only one facet of structure analysis, but it fills a gap in the literature and fills it very clearly and concisely. The book has been carefully edited, and, in view of the numerous illustrations and plates, is reasonably priced.

D. Rogers.

LINEAR CIRCUIT ANALYSIS

By B. J. Ley, S. G. Lutz and C. F. Rehberg

London: McGraw-Hill Publishing Co. Ltd. Pp. xvi + 567. Price 97s.

The present work is an excellent addition to the rapidly increasing number of books being published on network analysis and related subjects. The authors intend it for upper-class (*sic*—an American book, too) or first year graduate students; it would appear to be of the standard required for Final Year students reading Electrical Engineering in British Universities. Physics

students, except in special courses, would probably find it too detailed.

There is an elementary introduction to the subject, including a preliminary study of circuits involving vacuum tubes and transistors. Then, Chapter 2, the advanced work begins in no uncertain manner with network topology and matrix methods, subjects now accepted as essential in a modern University course in Electrical Engineering. Chapters follow on the steady-state solution of circuit integro-differential equations, on the classical transient solution thereof, on mechanical analogies, on Fourier analysis, the Laplace transformation and, a concluding chapter, on equivalent circuits and some circuit theorems.

The book is to be recommended, but again the price may well prevent it from being purchased to any extent by individual students.

J. D. Craggs.

MOVING ENVELOPES OF STARS

By V. V. Sobolev, translated by Sergei Gaposchkin

London : Oxford University Press. Pp. xiv + 106. Price 38s.

This book was a vital basis for research in 1947 when it was first available in Russian. Anyone reading this translated edition must realize that the books and papers by Kuiper, Struve, and Kopal have greatly altered the subject since then. In fact most of what is now known about the kinetics of gases in motion around stars is new since this book. There will have been no trouble over that fact at Harvard Observatory where the translator is, and where research is always up to date ; but in less enlightened places it will be important to read alongside such modifications as Kopal's recent *Close Binary Systems* (reviewed in this *Bulletin*, Dec. 1959) will reveal. But the mathematical methods developed by Sobolev are of permanent value, and will long continue to guide research even though physical interpretation has gone ahead with the dozen years of observed facts between ; astronomers will continue to be grateful to Dr. Gaposchkin and Mrs. Gaposchkin for their presentation to us of the great Leningrad astrophysicist.

Martin Johnson.

ELECTROMAGNETISM AND RELATIVITY (2nd EDITION)

By E. G. Cullwick

London: Messrs. Longman and Green and Co. Ltd. Pp. xxiii + 291. Price 63s.

That a second edition should be called for only two years after the publication of the first edition is an indication of the success which this book has achieved.

It is primarily concerned with the electromagnetics of moving media, the early chapters developing a simple first order theory. Part II deals with the general laws of electromagnetic induction, Wilsons' experiment, electromagnetic induction in conducting fluids, etc. Part III considers second order effects in the relativistic theory of electromagnetic induction in moving circuits. The last part of the book is concerned with electromagnetic energy and momentum.

Compared to the first edition the author has made some amendment and clarification in Chapters 18 and 19 of his theory of the equivalence of magnetic energy and the kinetic energy of the conduction electrons in a non-radiating current circuit. The most extensive change, however, is in the section of Chapter 5 dealing with the clock paradox which has been completely rewritten. The author has withdrawn from the position he took in the first edition of disagreeing with the calculation of the mathematicians that the clock of the returning space traveller will record a smaller lapse of time than that of his twin who had remained at rest in the one inertial frame.

He refuses, however, to accept completely the implications of the calculation. To quote his own words he " accepts the theory as providing a specification of electromagnetic phenomena which is remarkably successful, but not necessarily as a fundamental theory of space-time embracing all natural phenomena."

A. W. Gillies.

THE OTHER SIDE OF THE MOON

Translated from the Russian by J. B. Sykes

Oxford: Pergamon Press Ltd. Pp. 36. Price 10s. 6d.

On October 4, 1959, the Russians launched their lunar space rocket. This is the official account of the event, issued by the U.S.S.R. Academy of Sciences. It describes the automatic interplanetary station, with its arrangements for photography, processing, and transmission, and for orienting itself by the sun, and discusses in some detail the technical problems and their solution. Three photographs are given, together with the results obtained from their preliminary study. This is essentially a popular account, and a fuller scientific publication is promised shortly. Much of this information was given in the world press at the time, but memories are short, and this excellently produced publication will be welcomed as a permanent record of an important achievement.

G. R. Noakes.

The Institute's Journals

PRINCIPAL CONTENTS OF THE JULY, 1960, ISSUES

British Journal of Applied Physics : Volume 11, No. 7

Design and performance of a compact surge generator. By E. Thornton.

A compact surge generator for investigation of a fast, linear, pinched discharge using only moderate energy storage is described. The technique of construction using an explosive switch to obtain low inductance, and the method of measuring current are discussed. The behaviour of the surge generator when short circuited is determined from the current waveform, and inductance and resistance values are deduced. The inductance and resistance of the switch are much less than those for the whole circuit, with a linear discharge in deuterium.

Optical methods for the study of flames in turbulent pre-mixed gas streams. By M. D. Fox, Grad.Inst.P., and F. J. Weinberg, A.Inst.P.

Three optical methods for the investigation of flame processes in turbulent gases are described. All are based on ray deflexion by the steep refractive-index gradient occasioned by large temperature and composition changes across the flame front. This is utilized in three different optical systems designed (1) to give a measure of the randomness of orientation of the fluctuating flame front in any locality ; (2) to delineate the instantaneous flame-front surface ; and (3) to map time-mean deflexion (and hence optical path) distributions. Their purpose and use is discussed and illustrated by examples of the records obtained.

A study of large strains and the effect of different values of Poisson's ratio. By H. Fessler and B. H. Lewin.

The frozen-stress photoelastic technique was used to study the stresses on the inner surfaces of T-junctions of pipes subjected to different internal pressures. The peak stresses were always proportional to the applied pressure. The peak strains at a T-junction of hollow pipes under diametral compression were measured for identical shapes, made of materials of different Poisson's ratios. Within the limits of experimental accuracy, the peak strains were found to be independent of Poisson's ratio.

Strength of irradiated drawn and undrawn nylon. By C. C. Hsiao, Y. C. Das and A. Haynes.

This investigation describes the effect of reactor irradiation on the strength properties of oriented and unoriented nylon filaments. It is found that both the ultimate strength and the elastic modulus of the undrawn sample decreases markedly to a minimum upon receiving a reactor radiation indexed by the thermal neutron component of 6×10^{17} nvt as compared with that of the drawn sample. However, at somewhat higher levels of irradiation the ultimate tensile strength and the modulus of elasticity of the undrawn nylon increases while that of the drawn nylon continues to decrease until they approach to nearly the same level. At still a higher dose of reactor irradiation the ultimate tensile strength of both drawn and undrawn samples drops sharply while the modulus of elasticity increases sharply.

Variation of permanent-magnet properties with crystal orientation in columnar crystal alloys. By M. McCaig, F.Inst.P., and W. Wright.

The crystal orientations of three casts of a columnar permanent-magnet alloy have been compared. The same alloy has also been cut and tested at various angles to the columnar axis. Coercivity and $(BH)_{max}$ fall off less rapidly with angle than is predicted by Stoner and Wohlfarth, but may agree better with more modern theories, some of which have not yet been worked out in a form suitable for comparison. It is concluded that variations in the properties of columnar permanent-magnet alloys are still not wholly accounted for, although spread of crystal orientation may be a contributory factor.

Power law for creep. By B. J. Rigby.

A model is discussed which gives rise to the widely used power law for creep under constant load, namely, $dl/dt = \Omega t^{-n}$, where l is the strain, t the time, Ω a function dependent on temperature and load and n an exponent which may have any value between 0 and 1. In this model, the exponent n is interpreted as a function of the number of "flow units" which must be activated simultaneously before flow can take place.

Experimental and theoretical investigations on the oscillating cylinder viscometer for Newtonian liquids. By the late Ali Abdel Kerim Ibrahim and Abdel Monem I Kabiel.

A new and exact theory of the oscillating cylinder viscometer is given for Newtonian liquids. The final solution is not a direct relation between the measured quantity u (ϕ_0 (u being the angular displacement of the suspended cylinder and ϕ_0 the displacement of oscillation inexorably imposed on the outer cylinder) and the desired quantity η (η is the coefficient of viscosity), since the Bessel function involves η. To render this direct and applicable to Newtonian liquids a dimensionless parameter is introduced into the final solution. The theoretical relation which is derived subject to the condition that η is proportional to n (n being the frequency) satisfies the experimental curve which is subject to the condition that η is constant, at only one point ; hence from the co-ordinates of this point and the dimensionless parameter chosen, the value of η can be determined. Experiments have been carried out on different concentrations of glycerol. The results obtained confirm the validity of theory and method.

The extension of this method to non-Newtonian liquids will be given later in another paper.

Method of recording low-angle X-ray scattering when intensity scattered by specimen changes rapidly with time. By P. W. Teare.

A new technique is described for the collection of scattered X-ray intensity data at low angles. The technique is applicable to specimens producing scatter that is time variant. The use of the method is illustrated by an example taken from an age hardening aluminium-zinc alloy. Two methods of recording the intensity data are discussed and it is thought that an improvement in the facility of recording could be obtained by the use of proportional counting.

Influence of temperature on the spectral composition of the zinc sulphide luminescence. By I. Soudek.

The temperature dependence of the spectral composition has been presented by a new method which shows better the relative changes of the form of the emission band. On the main emission band of some zinc and zinc-cadmium sulphides, between the liquid air temperature and the temperature break-point, certain effects have been observed ; these are that (*a*) below 180°K the short wave side of the emission band of all phosphors grows faster than the long wave side with increasing temperature, (*b*) that in the neighbourhood of 220°K, the intensity of the whole band has a minimum for all copper-activated and copper-contaminated phosphors, and that (*c*), above 220°K, some phosphors behave inversely

as (*a*). These effects can be explained by the existence of two temperature-dependent processes having inverse influence on the form of the emission band, one being similar to the hole-migration process and the other being in connexion with the thermal liberation of trapped electrons.

Thermal propagation of a normal region in a thin superconducting film and its application to a new type of bistable element. By R. F. Broom and E. H. Rhoderick.

The movement of the interphase boundary due to Joule heating in a partially superconducting film carrying a current is analysed. It is shown that there is a value of the current at which the boundary remains stationary ; above this value the normal region grows, and below it, the normal region collapses. As the current approaches the critical current of the film, the speed of propagation becomes very large and of the right order to explain the authors' previous observation on the rate of return of resistance to thin superconducting strips driven into the normal state by rectangular current pulses.

The current required to maintain the boundary stationary is much less than that necessary to generate a normal region initially. This enables a new type of bistable element to be constructed, consisting of a strip of superconducting film carrying a continuous current equal to that necessary to maintain the boundary stationary. A short pulse of current in the same sense as the standing current generates a normal region in the film which is subsequently held constant by the standing current, while a short pulse in the opposite sense cancels the standing current long enough for the film to become completely superconducting again. This device is extremely simple in construction and can be switched from one state to the other in 10 mμs.

Etch pits and dislocations in cadmium sulphide crystals. By J. Woods, A.Inst.P.

A technique is described for producing dislocation etch pits on (0001), (000$\bar{1}$) and (10$\bar{1}$0) growth faces of cadmium sulphide crystals. Methods are also described whereby the dislocations are decorated by precipitation of either gallium or copper. The strongest proof that the etch pits are formed where dislocation lines cut the free surfaces is provided by (1) the characteristic etch pattern formed after indentation ; (2) the densities of etch pits in intersecting low-angle grain boundaries ; and (3) the coincidence of etch pits and decorated lines. Various other observations support the main evidence.

In conclusion, it is shown that the dislocation content can play an important part in determining some of the electrical properties of the crystals. In particular, copper is rendered ineffective as an acceptor by precipitation, and dislocations introduced in cadmium sulphide/chlorine crystals by plastic bending lead to the formation of acceptors.

Half-life of iridium 192. By J. W. Allison.

Using a null method, an ionization chamber and vibrating reed electrometer were employed to compare the γ-ray activity of an ^{192}Ir source with that of a reference ^{226}Ra source over a period of 209 days. An analysis of the results by the method of least squares indicates a half-life of ^{192}Ir of 74·17 ±0·07 days.

Journal of Scientific Instruments : Volume 37, No. 7

Measurement of magnetostriction within the temperature range −196 to 400°C. By R. R. Birss, A.Inst.P., and E. W. Lee.

An apparatus is described which permits the magnetostrictive behaviour of small single-crystal or polycrystalline specimens to be investigated over a range of temperatures from −196 to 400°C. Resistance strain gauges are employed and the performance of a number of gauges has been investigated at these temperatures. Details are given of the techniques used to obtain a reliable overall strain sensitivity of 2×10^{-7} per mm deflexion of the indicating galvanometer. The procedure by which the single-crystal magnetostriction constants may be obtained from strain measurements at saturation is outlined for the case of a disk-shaped crystal in which the plane of the disk is normal to one of the three principal crystallographic directions.

New high-voltage multi-stage impulse generator circuit. By T. E. Broadbent.

A new high-voltage multi-stage impulse generator circuit is described. The circuit is based on conventional multi-stage impulse generator circuits but trigatrons are used in each stage in place of the sphere gaps used in conventional circuits. The triggering pulse necessary to fire each trigatron is derived from the breakdown of the previous stage. For all multi-stage impulse generators of this type (other than very small ones), the stray capacitance coupling between stages is sufficient to operate the trigatrons, and no extra coupling capacitance is required. With the new circuit, multi-stage generators operate over a much greater range of voltage for given gap spacings in the various stages than is the case with the conventional circuits. The need for the spark gaps in each stage to be critically set is thereby eliminated. The results of an experimental comparison between the new and conventional circuits are described.

Magnetically operated mass-marker. By J. J. Brown, R. I. Reed, and W. Simpson.

The construction and operation of a magnetically operated mass-recorder which is suitable for use with the mass-spectrometer, type M.S.2 (by Metropolitan-Vickers Electrical Co. Ltd.), is described. Certain precautions in its operation are discussed. On the present evidence it operated with such accuracy as to be useful in a mass-range of up to 500 mass-units.

Liquid-nitrogen cryostat for single-crystal X-ray diffraction. By A. E. Attard and L. V. Azaroff.

The cryostat employs a continuous flow of precooled gas to maintain a small single crystal mounted on a fibre at −190°C ±2°C. The cooling chamber is completely enclosed so that a relatively small amount of coolant is required. Higher temperatures can be maintained to within two degrees by simply decreasing the gas flow rate.

Large storage binary-to-decimal converter. By G. Dearnaley, L. G. Lawrence, and H. C. Tresise.

An accurate binary-to-decimal converter is described capable of dealing with numbers up to 2^{24}. The instrument is designed for manual input with display on dekatron indicators, and a speed of operation of four bits per second.

Growth of single crystals of anthracene. By J. N. Sherwood and S. J. Thomson.

Single crystals of anthracene have been grown from melts of zone-purified material, in an all-glass oven. The important factors which governed the successful growth of single crystals by the moving-vessel technique have been investigated, *viz.* the purity of the anthracene, the temperature gradient, the shape of the growth vessel and the growth rate.

Wide-band detector for micro-microampere low-energy electron currents. By T. E. Everhart and R. F. M. Thornley.

Electrons with a mean energy of a few electron volts emerging from a source a few millimetres in diameter are accelerated on to a positively biased plastic scintillator. The light generated in the scintillator is guided by a Perspex light-pipe to a photomultiplier. If the scintillator bias is greater than 10 kV, no noise is introduced by the scintillator-light-pipe-photomultiplier system. If the original electron signal is modulated, the maximum modulation frequency transmitted by the system is greater than 10 Mc/s. The minimum detectable current is limited by the photomultiplier dark current, and may be less than 10^{-15} A with a suitably chosen tube.

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The Governors invite applications for post of ASSISTANT LECTURER, Grade B, in the Department of Physics. Applicants should possess an Honours Degree in Physics and have had research or industrial experience in some branch of applied physics. Teaching experience desirable. Burnham Technical Scale salary — £700 × £27 10s. to £1,150 with additions for degree and training. Placing on scale dependent on teaching and approved industrial experience. Application form and details from Registrar, College of Science and Technology, Ashley Down, Bristol, 7.

UNIVERSITY COLLEGE OF THE WEST INDIES

Applications are invited for (*a*) Lectureship or (*b*) Assistant Lectureship in Physics. Salary scales (under review): (*a*) £1,150 × £50 – £1,450 × £75 – £1,900 p.a., (*b*) £950 × £50 – £1,050 p.a. Entry point determined by qualifications and experience. Child allowance. F.S.S.U. Unfurnished accommodation at rent 5% basic salary. Passages for up to 5 persons on appointment, normal termination and study leave (once every 3 years). Duties to be assumed as early as possible. Detailed applications (6 copies) naming 3 referees as soon as possible to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further articulars may be obtained.

APPLICATIONS invited from PHYSICISTS with degree or equivalent qualifications for researches in a laboratory concerned with the behaviour of printing inks and adhesives. Knowledge of these materials not essential. Salary £650–£1,150. Superannuation, 5-day week, 3 weeks holiday. Application form from the Secretary, Printing, Packaging and Allied Trades Research Association, Patra House, Randalls Road, Leatherhead. Please quote ref. AP/RL.

EXPERIMENTAL OFFICERS AND ASSISTANT EXPERIMENTAL OFFICERS (male) required at Royal Military College of Science, Shrivenham, Berks., as Demonstrators in Civil, Mechanical and Electrical Engineering, Physics and Metallurgy. Qualifications: G.C.E. (Advanced Level); Pass Degree; H.N.C. or equivalent. Salary ranges: Experimental Officers (minimum age 27) £954 to £1,166. Assistant Experimental Officer £382 (age 18) to £830 p.a. Possibility of pensionable posts and promotion. Quarters available at the College for single men; possibility of housing for married men. Application forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.289/OA.

ASSISTANT PHYSICIST required for work on X-ray Crystallographic Analysis with a metallurgical bias and General Physical problems. Previous X-ray experience not essential but applicants should be of H.N.C. or Pass degree standard with some industrial experience. Preferred age group 21-30 years. Please write to the Personnel Manager, Fairey Aviation Ltd., Hayes, Middx.

ROYAL TECHNICAL COLLEGE SALFORD

DEPARTMENT OF PURE AND APPLIED PHYSICS

Applications are invited for a RESEARCH DEMONSTRATORSHIP for which an annual award of £350 p.a. is available, renewable up to a maximum of three years. The Demonstratorship will be awarded for experimental research in physics, the field of research to be connected with metal or polymer physics. The successful candidate will be expected to read for a higher degree. Applications stating age, qualifications and experience and indicating the preferred line of research, should be sent to the Registrar, Royal Technical College, Salford 5, Lancs., as soon as possible.

THE

PLASTICS DIVISION

OF

IMPERIAL CHEMICAL INDUSTRIES LIMITED

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HONOURS GRADUATES

in physics with research experience who are interested in the application of classical physics to high polymers with particular emphasis on the investigation of the relationship between properties & structure.

Pension and Profit Sharing schemes are in operation and for married men, temporary lodging allowances are available and assistance is given toward house purchase and removal expenses.

Apply briefly to:

The Staff Manager
IMPERIAL CHEMICAL INDUSTRIES LIMITED
Plastics Division
Black Fan Road
Welwyn Garden City
Herts

quoting reference No. 3106

THE
PLASTICS DIVISION
OF
IMPERIAL CHEMICAL INDUSTRIES LIMITED

requires an

HONOURS GRADUATE

in Physics to join a group studying the structure and texture of polymer specimens by optical and electron-microscopic methods. Knowledge of the principles of optical systems, birefringence and crystal optics, together with experience of microscopic methods, are necessary. Some experience of academic or industrial research is desirable

Pension and Profit Sharing schemes are in operation and for a married man, a temporary lodging allowance is available and assistance is given toward house purchase and removal expenses.

Apply briefly to :

The Staff Manager
IMPERIAL CHEMICAL INDUSTRIES LIMITED
Plastics Division
Black Fan Road
Welwyn Garden City
Herts

quoting reference No. 3104

The Osram Lamp Division of The General Electric Company Limited

wishes to appoint a

GRADUATE

PHYSICS

OR

ENGINEERING

to lead a development team on problems associated with the design and manufacture of discharge lamps. Opportunity for man under 30, ready to take responsibility and with aptitude for working with Research and Production groups. Interesting opportunity to assess the value of new techniques or theories in the illumination field and to develop ways of incorporating these in lamps produced by highly mechanized production processes.

The appointment would be initially in the development Laboratory at Shaw, Lancashire, and applications should be sent to :—

The
Senior Personnel Officer,
Osram Lamp Division,
G.E.C. Estate,
East Lane,
North Wembley,
Middlesex.

ROYAL MILITARY COLLEGE OF SCIENCE, Shrivenham, Berks, requires GRADUATE DEMONSTRATORS (male) in Civil, Mechanical and Electrical Engineering Physics, Metallurgy and Ballistics. Teaching is at university level. Demonstrators required to assist in supervision of students' laboratory work and in research undertaken by staff and students. Extensive well-equipped laboratories. Demonstrators encouraged to engage in personal research towards higher degree. Qualifications 1st or 2nd class honours degree or equivalent. Salary range £650 – £785 with superannuation under F.S.S.U. Appointments normally for three years but may be extended. Quarters available for single men; possibility of houses for married men. Forms from Ministry of Labour, Technical and Scientific Register (K) 26, King Street, London, S.W.1, quoting A.266/OA.

THE
ROYAL TECHNICAL COLLEGE OF EAST AFRICA AND PROPOSED UNIVERSITY COLLEGE IN NAIROBI

Applications are invited for the newly instituted CHAIR OF PHYSICS. Salary scale : £2,500 × £100 – £2,600 p.a. Superannuation. Child allowance £50 p.a. per child (maximum £150 p.a.) Passages for appointee and family (up to four adult passages) on appointment, termination and leave (once every two years). Rent according to quarters provided, £60–£114 p.a. Detailed applications (eight copies) naming three referees by July 25, 1960, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

SENIOR LECTURER IN PHYSICS required by ROYAL MILITARY COLLEGE OF SCIENCE, Shrivenham, Berks. Teaching is at university level. Selected candidate to lecture to degree courses (and possibly specialized courses) and assist with laboratory classes. Also expected to engage in research, preferably in connection with nuclear physics, radiation physics or solid state physics. Work would be suitable for publication and submission for higher degree. Qualifications: First or second class honours degree or equivalent in physics, preferably with teaching and/or research experience. Minimum age 26. Salary range £1,166–£1,380 (male) superannuation under F.S.S.U. Good prospects of permanency. Quarters available for single man; possibility of house for married man. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.265/OA.

WARWICKSHIRE EDUCATION COMMITTEE
RUGBY COLLEGE OF ENGINEERING TECHNOLOGY

LECTURER IN PHYSICS. A vacancy exists in the Department of Science and Mathematics for a Lecturer in Physics. Applicants should be well-qualified physicists with research and/or industrial

ELECTRICAL ENGINEERS OR PHYSCISTS

(ELECTRONICS)

The Billingham Division of Imperial Chemical Industries Limited has vacancies for **GRADUATE ELECTRONIC SPECIALISTS** in the Physics group of its Research Department. These involve original experimental work on the development of new physical methods and instruments for the study and measurement of physical and chemical phenomena. Some of these methods may be used in the study and control of large scale processes. In these tasks the Group is concerned with a very broad range of experimental techniques ; electronics, X-ray fluorescence and emission, electron optics, high vacuum techniques, nuclear magnetic resonance, X-ray diffraction, mass spectrometry, radioactivity and mechanics.

Excellent laboratory, workshop and design drawing facilities are available.

The applicant should have versatility and a flair for the electronic and mechanical design of experimental apparatus.

The appointments are pensionable and carry attractive salaries. There is a profit-sharing scheme in operation and assistance will be given married men towards house purchase and removal expenses.

Candidates are invited to write, giving brief details of qualifications and experience, quoting reference H/A/3 to :—

The Staff Manager,
IMPERIAL CHEMICAL INDUSTRIES LIMITED,
BILLINGHAM DIVISION, BILLINGHAM, CO. DURHAM.

experience, and should have, or be prepared to develop, a strong interest in the physics of materials. There will be opportunities for research. Salary scale within the Burnham Technical Report—£1,370 × £35 – £1,550. Further particulars and application forms may be obtained from the Principal, Rugby College of Engineering Technology, Eastlands, Rugby, to whom replies should be addressed as soon as possible.

OPPORTUNITY IN THE U.S.A. SOLID STATE PHYSICIST. Graduate training, Ph.D. or equivalent, 5-10 years experience, knowledge of solid state materials, theory, measurements. Familiar with techniques of growing, doping, junction formation, contact phenomena, etc., in the semiconductor field. This is an outstanding technical/financial opportunity in an old established component manufacturing concern in the U.S.A. The Company's representatives will visit London in July. Please send particulars to G. V. Planer Ltd., Windmill Road, Sunbury-on-Thames, Middlesex.

OSRAM LAMP DIVISION

REQUIRES PHYSICS GRADUATES

The Osram Lamp Division of the General Electric Co. Ltd., is interested in increasing its staff of Physics Graduates in the Incandescent Lamp Laboratory. Young and recently qualified Physicists are invited to join a team of engineers concerned with the development of new improved light sources and the physics of their design and processing. These posts offer opportunities not only for a responsible technical career, but also laboratory experience provides a useful "jumping off" point after training for production and administrative posts in other parts of the Osram Division. Apply giving details of qualifications and experience (if any) to the Senior Personnel Officer, Osram Lamp Division, East Lane, North Wembley, Middlesex.

FOURAH BAY COLLEGE – SIERRA LEONE

UNIVERSITY OF DURHAM

Applications are invited for appointment as LABORATORY SUPERINTENDENT in the Department of Physics. Salary Scale: £660 × £30–£720; £810 × £36–£990; £1,032 × £42–£1,116 p.a. plus a 10% contract addition. Entry point according to qualifications and experience. Outfit and family allowances (maximum £300). Passages on appointment, annual leave and normal termination. Gratuity payable in lieu of pension. Overseas allowance in appropriate cases. Part-furnished accommodation at reasonable rent. Detailed applications (six copies) naming three referees by July 31, 1960, to Secretary, Inter-University Council for Higher Education Overseas, 29, Woburn Square, London, W.C.1, from whom further particulars may be obtained.

UNIVERSITY OF QUEENSLAND

SENIOR LECTURER IN PHYSICS

Applications are invited for the abovementioned position. Applicants should possess a Doctorate of Philosophy or Science conferred for research in some branch of Physics. Some Lecturing experience is desirable but not essential. Salary £A2,160–£A2,510 p.a. Further particulars and application forms are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close in Australia and London on August 15, 1960.

ROYAL TECHNICAL COLLEGE, SALFORD

RESEARCH STUDENTSHIP

Applications are invited from physicists, electrical engineers or physical chemists with a first degree from the University of London for a research studentship in the Department of Electrical Engineering. The work is in the field of Ultrasonics and is suitable for submission for higher degree of the University of London. The Studentship is renewable annually up to a maximum of three years, and carries an award of £500 rising to £600 p.a. the commencing point may be above the minimum. Applications giving full particulars, together with the names of two persons to whom reference may be made, should be sent to the Registrar, Royal Technical College, Salford 5, Lancs., as soon as possible.

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THE UNIVERSITY OF SOUTHAMPTON, Department of Physics, offers a studentship of the value of £415 per annum for research on the thermionic and related aspects of the direct conversion of thermal to electrical energy. The work, sponsored by the Atomic Energy Research Establishment, involves application of the techniques of thermionic emission, contact potential and ultra-high vacua, and can lead to a degree of M.Sc. or Ph.D. Applicants, who should have good honours in a first degree in Physics, should apply to the Professor of Physics of the University of Southampton before July 16, 1960, giving the names of two referees.

COURSES

ROYAL TECHNICAL COLLEGE SALFORD

DEPARTMENT OF PURE AND APPLIED PHYSICS

RADIOLOGICAL HEALTH AND SAFETY

A postgraduate course in Radiological Health and Safety, of one academic year's duration, will be held during the forthcoming session, 1960-61. This is intended for graduates or those of graduate status and will deal with the principles and practice of radiation protection. Laboratory work will be an integral part of the course. Satisfactory completion will qualify for a College Certificate. The fee for the course is £81. Further details may be obtained from the Acting Head of Department.

THE COLLEGE OF AERONAUTICS

One-Year Postgraduate Course in Space Technology. Applications are invited for a course which begins on October 10, 1960. Applicants should generally be graduates in a branch of science or engineering or have equivalent qualifications. The course is designed to provide postgraduate training for future workers in the field of Space Technology and will consist of lectures, laboratory demonstrations and research projects conducted under supervision. Students will specialize in one of the Departments of the College, and conduct research, which may be either of a theoretical or an experimental nature, on a topic chosen in consultation with the College staff. In addition to attending lectures in their Department of Specialization, students will be expected to attend selected general lecture courses given by other Departments of the College. Students who successfully complete the course will be awarded the Diploma of Advanced Engineering (D.A.E.). Further information and forms of application may be obtained from The Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks.

BATTERSEA COLLEGE OF TECHNOLOGY, LONDON, S.W.11.

(PHYSICS DEPARTMENT)

The following Postgraduate Courses will be held during the Session 1960-61. Autumn Term begins October 3, 1960. 1. Microwave Physics (full-time and part-time) leading to M.Sc. The Department of Industrial and Scientific Research has accepted this course as suitable for tenure of its Advanced Course Studentships. 2. Radiation Physics and Radiological Protection (part-time and evening), leading to the Certificate of the College. 3. Rheological Techniques (evenings). Full details and enrolment forms from the Head of Department.